Improved Enhanced Dbtma with Contention-Aware Admission Control to Improve the Network Performance in Manets

M. Sivaram[1, *], D. Yuvaraj[2], Amin Salih Mohammed[3], V. Manikandan[4], V. Porkodi[4] and N. Yuvaraj[5]

Abstract: DBTMA relies entirely on RTS/CTS dialogue for un-collided transmission of data. The purpose is to improve the QoS at MAC layer by developing it over 802.11e standard. However, DBTMA does not guarantee real-time constraints without efficient method for controlling the network loads. The main challenges in MANETs include prediction of the available bandwidth, establishing communication with neighboring nodes and predicting the consumption of bandwidth flow. These challenges are provided with solutions using Contention-Aware Admission Control (CACP) protocol. In this paper, the EDBTMA protocol is combined with CACP protocol that introduces bandwidth calculation using admission control strategy. The calculation includes certain metrics like: admission control and bandwidth consumption. To compute the bandwidth of channel, bandwidth utilization and traffic priority is distinguished through dual busy tone is proposed. This operates distinctly on its own packet transmission operation. This CACP mechanism defends the conventional traffic flows from new nodes and based on the measured status information of the channel, it QoS of the admitted flows is maintained. This ensures maximum amount of bandwidth flows accommodated by resources and determines the resources in a system meet the new flow requirements while maintaining existing bandwidth flow levels.

Keywords: Edbtma, cacp protocol, mac layer, manets.

1 Introduction

The IEEE 802.11e MAC protocol improves the 802.11 CSMA/CA standard's contention technique that allows adjustment in previously fixed MAC parameters. IEEE 802.11e

[1] Department of Computer Networking, Lebanese French University, Erbil-44001, Kurdistan Region, Iraq.

[2] Department of Computer Science, Cihan University, Duhok- 42001, Kurdistan Region, Iraq.

[3] College of Engineering and Computer Science, Lebanese French University, Erbil-44001, Kurdistan Region, Iraq.

[4] Department of Computer Networking, Lebanese French University, Erbil-44001, Kurdistan Region, Iraq.

[5] Department of Computer Science and Engineering, St. Peter's Institute of Higher Education and Research, Chennai-600 54, India.

[*] Corresponding Author: M. Sivaram. Email: sivaram.murugan@lfu.edu.krd; phdsiva@gmail.com.

protocol is studied extensively in literatures and the present study almost confines to critical and simulation studies, which compares EDCA with proposed DBTMA. Due to severe lack of hardware devices, the experimental study could be conducted in evaluating the comparison performance of the 802.11 protocol with the proposed one. However, with available hardware, investigations over 802.11e EDCA protocol are done in real-time environment.

EDCA provides prioritized QoS that further enhances the contention based DCF. This offers a segregated and distributed access to all the wireless communicating medium for QoS stations that uses 8 dissimilar priorities of users. Formerly, each data packet that is received from the respective higher layer is been assigned with a specific values of user priority, before the packet enters the MAC layer. There is an issue during implementation, when the priority value is set for each packet. The EDCA technique provides 4 varied queuing namely first-in first-out (FIFO) queues. This is referred as access categories (ACs) that helps in supporting the traffic delivery with UP over the QoS stations. The data packet obtained from higher layer provided with specific value of user priority is mapped to its respective ACs.

A relative prioritization is used to root specifications from the bridge specification of IEEE 802.1d [Wietholter and Hoene (2003)]. Various types of applications (e.g., best effort traffic, background traffic, voice and video traffic) is directed over to ACs in the network. Each AC possess an enhanced DCF variant, named as enhanced distributed channel access function (EDCAF) that resists TXOPs in using EDCA parameter's set from the Set element of EDCA Parameter. Otherwise, the default parameter values are taken into consideration when there is no EDCA Parameter Set element is received. Additionally, there are certain issues in EDCA protocol over MAC layer, which is discussed in following section.

1.1 Issues in EDCA over MAC layer

EDCA possess two different collision types: first is classical collision/real collision that ensures two or more ACs that are active within two or more QoS stations. The selected Qos Stations are different, and they access the communication medium at same intervals. The second category of collision is a virtual or internal collision, which occurs when two ACs within same QoS station access the communication medium at the simultaneous intervals [El Masri and Abdellatif (2009)].

The IEEE 802.11 Wireless LANs (WLANs) is employed widely that ensures universal networking. This is completely due to its easier installation, flexible nature and robustness against node failures. Despite its broad dissemination, the IEEE 802.11 MAC protocol does not support real-time applications that are specific characteristics like timing jitter and packet delay.

This wireless MAC possess multi-data rate with routers and clients possessing varying data rates. The performance (throughput) of the IEEE 802.11 channel access behaves very poor or it degrades during channel access in multi-rate and overall networks [Li, Pal, and Yang (2008)]. The major problem essential in IEEE 802.11s communication is the fairness problem in EDCA multihop networks at MAC channel access protocol. The unfairness is evident in busty conditions and it is not resolved totally in multiple radios that is tuned on multiple access channels.

The IEEE 802.11 provides long transmission opportunities in each contending nodes of the wireless network. Additionally, it provides channel share proportionate with the data rate of the channel. In actual fact, the IEEE 802.11MAC adopts a fixed contented channel access schema that is termed as Distributed Coordination Function or DCF. This is based purely on CSMA/CA protocols that cannot provide definite networking services. These limitations could be overridden through certain innovations of 802.11e working group. The innovations include Hybrid Coordination Function or HCF that is otherwise an enhanced access method. HCF specifies signaling of messages over certain service request and QoS negotiations and 4 ACs using various priorities that maps the QoS requirements of the users.

Especially, HCF assigns Transmission Opportunities (TXOP) over each ACs for satisfying the needs of QoS. This takes place where TXOP is distinct as the time interval during which a station can transmit. This in turn is categorized based on the starting time and the total duration.

The design of QoS fairness possesses severe several disadvantages that specifically signify during diverse flow in traffic. The applications of diverse traffic flow include video, VoIP and TCP traffic that are active concurrently in the cell. Since, network is incapable in providing them the essential guaranteed service guarantees that includes constant bandwidth for real-time traffic flows. The unfairness problem is insignificant in IEEE 802.11s EDCA communication due to its severe dissimilarity in traffic load among clients and routers.

1.2 Impact of EDCA over MAC protocol

The MAC protocol is accountable for the distribution of transmission opportunities in channel. The transmission tries to deliver fair access or same channel share for all active nodes. This is considered without segregating the mobile stations (STAs) and access point (AP). Even though, the performance of EDCA protocol is found in MANETs, it is found that there is a limitation in its packet-level metrics. This includes various factors like delay; throughput and entire focus of EDCA behavior/impact over MAC behavior includes collision and transmission probabilities.

1.3 Impact of EDCA with DBTMA

Furthermore, the EDCA could be used with simple and RTS/CTS- channel access methods. The mathematical investigations are accomplished for both channel access with diverse limits on retransmission [Kosek Szott, Natkaniec and Pach (2011)]. However, the use of traditional CSMA/CA system provides hidden and exposed terminal problem that concedes the channel access with reduced capacity in network performance. The loss in chancel utilization is address in terms of various systems that includes RTS/CTS network. Hence the present study moves its concentration over a new MAC protocol that should accompany the RTS/CTS based channel access and considers the hidden and exposed terminal problems. Hence, Dual Busy Tone Multiple Access (DBTMA), a multiple access technique in MANETs for packet radio networks is considered for the current study.

2 Problem statement

Quality of Service is an important parameter that decides the trusted immediate nodes or hops. Routing through such nodes or hops should be efficient enough to deliver the packets to destination without intrusion. Certain defence, search and rescue operations required a better QoS, however, the availability of such QoS services is inhibited due to several constraints in MANETs. Here the present study discusses the major issues in MANETs namely: hidden terminal problem and exposed terminal problem [Jayasuriya, Perreau, Dadej et al. (2004)], which affects significantly the QoS performance MANETs.

2.1 Hidden terminal problem

Fig. 1 Illustrates the hidden terminal problem in MANETs. If a node that is hidden outside the range of transmission of a sender, however, it lies within the receiver range is considered as hidden terminal. Since the transmission of mobile node range is limited, multiple transmitters within the same receiver range could not have known about the existence of other transmissions. In this way, the nodes are hidden from each other. The nodes transmit in/around at the same time and the real problem is that they don’t recognize that there is a collision in its transmissions on the way to receiver.

Consider that there exist four nodes A, B, C, and D (Fig. 1). The communication range of each node is shown in dotted circle. Consider that the A node is in communication with B node. Assume, there exist a node C and that needs to transmit packets to D node. If the C Node senses that the channel as free, it could start its transmission, however, at node B, there exist a collision. This is considered as hidden terminal problem that significantly degrades the throughput performance in MANETs.

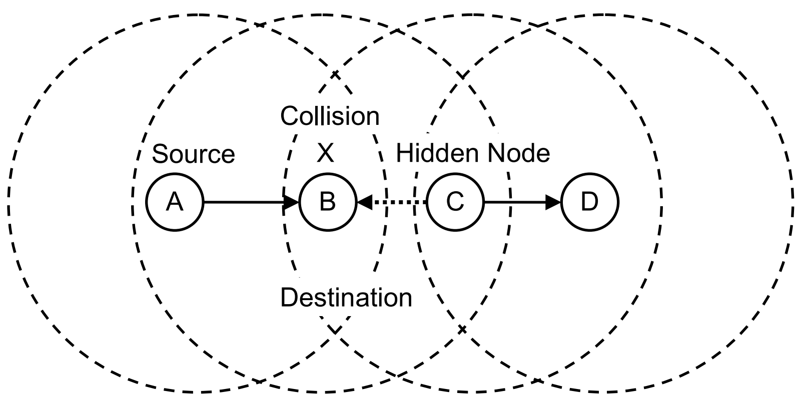

Figure 1: Problem identification - hidden terminal problem

2.2 Exposed terminal problem

Fig. 2 shows the exposed terminal problem in MANETs. Exposed terminal/nose is one, which lies in the transmission range and lies outside the reception range. The exposed node leads to underutilization of network bandwidth/capacity.

Consider that there exit four nodes in a network namely, A, B, C, and D (Fig. 2). Here, the node C wants to communicate with node D. If node B transmits the packets to node A and if Node B finds that the channel is busy, then it fails to transmit to node A.

Although the transmissions that happened cannot causes collision at node D, however, node B is allowed to stop its transmission. From this it could be inferred that the node B is considered as an Exposed Node. This probably leads to inefficient utilization of bandwidth at B node. Hence, the problem of inefficient bandwidth utilization due to B node is considered as exposed terminal problem.

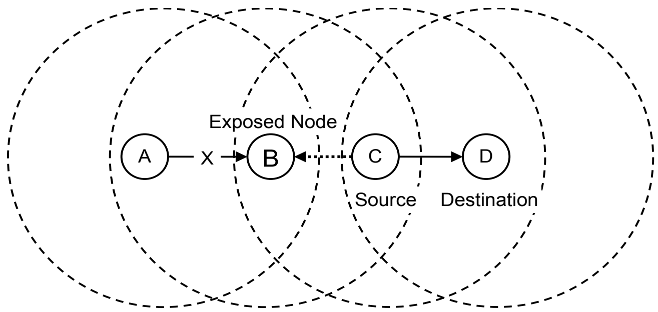

Figure 2: Problem identification-exposed terminal problem

The Hidden terminal and exposed terminal problems frequently occur in MANET that significantly degrades the throughput of the network. To overcome the hidden terminal and exposed node problem in MANETs, modified RDTMA and EDBTMA protocols are proposed.

3 Related works

The hidden terminal and exposed terminal problem are regarded as major concern in MANETs. Conventional methods provide various opportunities for the networks to get rid of such terminal issues. However, there are certain disadvantages associated with the conventional methods. This chapter provides a detailed insight on collision avoidance, hidden terminal and exposed terminal problems and fairness problem in conventional EDCA and DBTMA protocols. The comparison between EDCA and DBTMA is considered since, they are basis protocols in IEEE 802.11e suite. The IEEE 802.11e standard provides an ultimate powerful supporting platform for QoS in Wireless networks. Hence, EDCA protocol is chosen for the comparison purposes.

3.1 Dbtma techniques on hidden and exposed terminal problem

The main aims of the MAC protocol are to provide synchronized multiple nodes access over shared communication medium. This maintains higher utilization network. Here, hidden and exposed terminal problem in conventional literatures tries solving or improve the performance in MAC scheme over single/multi-hop networks.

Deng et al. [Deng and Haas (1998)] proposed Dual Busy Tone Multiple Access (DBTMA) technique in packet radio networks. They tried to solve the hidden and exposed terminal problem in MAC protocol to improve the bandwidth utilization. To achieve these RTS/CTS dialogues are used, however, such schemes possess higher performance degradation basic access method. Henceforth, degradation in utilization, propagation and long transmission delays could lead to poorer performing network. In addition to RTS/CTS, dual busy tones separate the usage of forward and reverse communication. The performance results of dual busy tone are twice the time effective as RTS/CTS signaling method.

Haas et al. [Haas, Deng and Tabrizi (1999)] proposed a scheme where each node uses dual out band busy tone signals along with RTS/CTS dialogues. The dual out band tones work for notification purpose over entire node within the range of transmission and reception. The assurance of hidden and exposed back-off terminals, however, does not defer. The dual busy tones are regarded as narrow band signals with extra hardware requirements are limited in this literature. Dual busy tones are sensed as meek and implemented using narrow band comparator and filter. The use of busy tones in MAC protocol, possibly helps in using variable packet length for transmission purpose.

Haas et al. [Haas and Deng (1999)] proposed the DBTMA scheme to operate in a decentralized network like Packet Radio Networks. The usage of RTS/CTS dialogue reserves DBTMA channel. Additionally, two busy tones are used for notifying the neighboring nodes with effective channel reservation in current packet transmission and reception. The performance analysis proved that the DBTMA protocol delivers higher utilization of network that is 100% more than RTS/CTS dialogue schemes.

Haas et al. [Haas and Deng (1999)] designed DBTMA scheme for multi-hop distributed networks with RTS/CTS dialogue mechanism. This protocol reserves the channel to be shared in multi-hop environment. Nodes in transmitter and receiver range cannot hear the successful RTS/CTS exchange of message. This leads to destruction of data and data access collisions. Thus, two busy tones with narrow bandwidth are used and that notifies neighboring nodes with current channel transmissions. The capacity of channels is analyzed using DBTMA protocol. Various network utilization parameters over multihop networks provides analysis on the DBTMA performance with RTS/CTS dialogue schemes. The DBTMA scheme proved with better collisions prevention than other schemes.

Haas et al. [Haas and Deng (2002)] address again the problem of hidden and exposed terminals and proposed a modified RTS dialogue scheme. The MAC schemes that use RTS/CTS cannot solve terminal problems, hence the MAC schemes are considered to be fully in-secured in connected wireless networks. Hence, a MAC protocol with DBTMA scheme is proposed and its operation on RTS packet with 2 narrow bandwidth and outband busy tones is used. The RTS packet is installed using the receiver along with a busy tone. The busy tone set up by transmitter completely provides full protection for RTS packets and it increases the successful RTS reception probability. Consequently, this has increased the network throughput. Simulation provided the analytical results and the DBTMA protocol performs superior than other RTS/CTS schemes over one channel and that rely over single busy tone.

Zhai et al. [Zhai, Wang, Fang et al. (2004)] studied the inefficiency of networks due to hidden and exposed terminal problem, blocking problem of receiver and an intra-flow contention problem. These problems lead to detonation in control packets providing very poor throughput performance. Thus, MAC protocol for IEEE 802.11 wireless network is proposed. The proposed MAC protocol with features includes an architecture with a two communication wireless channels and outband busy tone. Along with this the control and data frames are included. The procedure for exchanging the message provides inclusive solution to these four problems. This scheme provides a better performance over the four problems that could improve greatly the spatial reuse and eliminate the data packet collisions. A stable link layer that possess few control overheads proved well the performance with less routing failures. Consequently, the throughput of the system is improved well than the 802.11 MAC system.

[Yeh (2004)] identified multiple unique problems over multihop wireless networks. An interference aware multiple access scheme MAC in multihop adhoc and wireless LAN networks. Depending on the CTS (triggered), dialogues-detached and object to sending mechanisms, these schemes are used. The interference aware multiple access is a distributed MAC scheme that solves the additive interference problem using common channel that is shared by data packets and control messages. The distributed MAC scheme achieves the interference that does not rely on busy tone with a dual transceiver. Interference aware multiple access solves the heterogeneous hidden terminal or exposed terminal problem with adjustable power that does not rely on hardware for signal strength measuring and supports the multiple access and interference in directional antennas.

Yu et al. [Yu and Yin (2005)] presented a joint Physical layer MAC design in a wireless adhoc networks. This syndicates the DBTMA integrated with physical system with modifications over orthogonal frequency division multiplexing system that is proposed in 802.11a. The performance analysis indicates that this scheme provides better performance than 802.11 MAC protocol with lesser complexity than other solutions. Additionally, the system is made compatible with 802.11a wireless networks.

Leng et al. [Leng, Zhang and Chen (2005)] proposed a dual MAC schemes for solving the hidden terminal and exposed problem in the wireless adhoc networks. This method possesses a larger range of interference. Further, the usage of dual busy tones in a single scheme is provides an improvement toward 802.11 networks. The second scheme signifies exactly the range of interference that adjusts the busy tones' transmission power. These two schemes prevent the data packet or acknowledgement packet collision. The results proved that the two schemes enhance significantly the throughput (saturation) of 802.11 wireless networks. The method further provides a balance between or a trade-off between collision avoidance and spatial reuse.

Wang et al. [Wang, Jiang and Zhuang (2006)] proposed a busytone MAC scheme that supports the data or voice traffic address the problems of hidden terminal and exposed terminal problem. Dual busy tone narrowband separate channels with varied ranges of carrier sensing resolves completely the hidden and exposed terminal problems. Additionally, the extension of busy tones over the busy tone transmitter channel, the scheme guarantees the voice traffic independent priority access over delay sensitive schemes over certain user locations. The long and short term QoS performance to required data traffic over multi hop wireless environment has improved greatly than 802.11e MAC schemes.

Wang et al. [Wang and Zhuang (2006)] enhanced the conventional busytone dialogues for resolving the collisions in RTS occurs due to hidden terminals. The addition of two separated busytone and setting of various ranges of carrier sensing over different channels avoids collisions completely. This includes the data packets and RTS collisions that is caused due to hidden terminal problem. The carrier sensing range setting of transmitter busy tone is twice the carrier sensing range of receiver channels and avoids 100% collision due to hidden terminals.

Wang et al. [Wang and Ali (2006)] studied the modeling of MAC protocol for wireless adhoc networks. DBTMA is considered to solve the hidden terminal and exposed terminal problem. The conventional evaluation performance of DBTMA failed in considering the hidden terminal problem. Hence to improve the performance analysis, hybrid MAC protocol of Channel Reservation and Busy Tone technique is proposed to consider the aforementioned problem. The performance evaluation failed to provide higher throughput results than the conventional DBTMA model.

Yuan et al. [Yuan, Zhu, Liu et al. (2007)] proposed Combined DBTMA protocol that uses a single busy tone channel for implementing the entire functions the DBTMA possess. This significant does not losses the system performance. The hidden terminal and exposed terminal problems with less capacity wastage is considered. However, end to end delay is longer than DBTMA technique because of additional delaying parameter. Hence, this technique is considered useless for impending wireless LAN without terminal problems.

Yeh [Yeh (2007)] proposed the detached busytone method as a solution to get rid of receiver busy tone self-interference. The busytone is transmitted in the form of outband narrow tone signals that helps in transmission of associated data packets. Hence, an advanced busytone multiple access method (ABTMA) is proposed with dual busytone. Additionally, several such advanced subclasses protocol that includes pure ABTMA, collision avoidance ABTMA and RTS-ABTMA with its respective gains. Specifically, the shortened busytone method reduces significantly the identified overhead problem occurring due to induced idleness dialogues. This exists in RTS/CTS dialogue-based MAC for 802.11 or 802.11e protocols with control channels. Also, a self-interference busy tone cancelation method for inband and mixed approach coexist in CSMA or 802.11 or 802.11e wireless networks or busy toneless frequency hopping networks. The busytone detached, busytone shortened, and self-interference busytone cancelation provides better performance throughput than PCMA and DBTMA. However, DBTMA performs well with the use of RTS/CTS signaling.

Kalfas et al. [Kalfas, Papadimitriou, Nicopolitidis et al. (2007)] studied the extremely vulnerability in adhoc networks due to hidden terminal and exposed terminal problems. This results in subsequent reduction of network capacity. The lack of knowledge over surrounding scenario, an in-wrought characteristic over with wireless adhoc networks, is the major purpose for the performance degradation in MANETs. To problems are addressed effectively using Wireless Medium Access Record Keeping methods that combines the table-driven busy tone with power control protocols. Here, each node has local matrix relation that stores the on-going condition of adjacent nodes. The matrix records are updated periodically using status messages of transmission that possess RTS dialogue that initiates the transmission of data packets. The status messages get secured with busy tones for getting highest priority and maximize the probability of successful transmission. Finally, the power control scheme assures the allocation of best possible bandwidth allocation for wireless networks with maximum throughput.

Wang et al. [Wang, Jiang and Zhuang (2008)] proposed a busytone MAC scheme that supporting data and voice traffic for address the hidden and exposed terminal problems. A two-narrow band busytone separated channels possessing varied carrier sensing ranges resolves the terminal problems. Besides, the use of busy tones for transmitter node with a back-off method, ensures the priority guaranteed access over delay sensitive traffic networks like voice over data traffic networks. The priority is locations independent depending on the user and it solves the problem of reverse priorities. The performance of fairness indications over data traffic is not connected fully with the scenarios that are improved greatly than 802.11e MAC protocol. This does not need an additional information to exchange packets between the neighbouring nodes.

Liu et al. [Liu, Leng, Fu et al. (2009)] combatted the exposed terminal problem and the phenomenon of accumulating interference over wireless network channel. To resolve this issues, asymmetrical dual busy tones MAC protocol was proposed. The introduction of busy tone CTS dialogue mechanism along with the use of interfering node estimation algorithm solves the problems of exposed terminal and hidden terminal in large interference environment/ range. Further, the effects due to phenomenon of accumulating interference for busy tones is relieved through power adjustment method.

Chen et al. [Chen and Li (2011)] proposed Hybrid Channel Reservation and Busy Tone protocol that is treated as a solution for the hidden terminal and exposed terminal problem. This responds well to the real-time transmission systems using reservation of channels and dual busy tone. Typically, the information about channel reservation is transmitted in the form of linked packets. Though, the proposed technique uses busy toneto overcome hidden terminal and exposed terminal problems and broadcasts the information about channel reservation. The performance results proved that the proposed protocols provide higher stability while reserving a channel. This has improved significantly since the reception of the information about channel reservation provides serious effects the existence of hidden terminal and exposed terminals problems.

Poudyal et al. [Poudyal, Bhattacharjee, Panigrahi et al. (2012)] studies the lack of infrastructure, hidden terminal and exposed terminal problem, dynamic topology and other challenges in MAC wireless networks. The behaviour of two MAC protocols namely multiple access collision avoidance for wireless and DBTMA is studied. The performance evaluation is considered in terms of QoS via bandwidth utilization. The results provide suitable various network topologies for MAC protocol and provides guidelines for robust and efficient MAC protocols design.

This section provides an insight of various techniques and its performance level in terms of the problems that are in existence with EDCA and DBTMA protocols. Additionally, the usage of RTS/CTS dialogue mechanism in EDCA motivated the study to consider the problems associated with EDCA and to provide a relationship with the DBTMA protocol.

3.2 Throughput and delay analysis of DBTMA

For an active node, the probability of packet transmission (RTS) over a node in a dedicated time slot is a. The probability of collision of the packet transmission with other packets is p. When the probability of packets, a and p interacts with one another. If the value of a is larger, then the probability of collision, p is increased and if the value of p is larger, then the nodes increases the durations that makes the value of a to reduce further.

In steady state, assume a and p of a tag node is constant. Consider the network to be homogeneous, i.e., the total number of neighboring nodes for each individual node is a constant one. Then assume a and p possess same value for all individual nodes. Hence, to understand the performance of the network, the value of a and p are found to be in steady state.

4 Proposed method

The throughput of a channel over a single transmission area with total number of nodes using DBTMA is considered as an analytical model with following assumptions:

- The transmission time of DATA packet, the transmission time of RTS/CTS control packet and time of propagation: δ, γ and τ .
- Consider, N similar nodes located over a single transmission area. Each node generates DATA packets with Poisson arrival distribution.
- The complete traffic load with arrivals, λ over each unit time, δ . Henceforth, the DATA packets arrival rate of each individual node is denoted as λ =/N.
- The arrival of each individual node while processing a packet or blocked by the node is discarded.

To calculate the throughput of a channel, a busy period signaling over a channel with transmissions within a period is considered in between two successive periods. However, a busy period signal may also possess successful transmission of DATA or collisions of packets.

4.1 Packet transmission probability

Consider a node that transmits a RTS packet form transmitter to the intended receiver. The receiver waits over a longer time long to acquire CTS packet. Hence, each request blocks the node that accepts the newer arrivals for the time t=2y+τ seconds. The probability of idle node is represented as:

$P_i=(\lambda+1)/(\lambda^{-1}+t)$

Since, entire nodes are located within same area, RTS is successful and BTs is setup, then transmission of DATA packets is treated to be collision resistant. The probability of successful RTS packet at the time is similar to the probability of sending only the RTS packets for transmission, provided that there exists a single channel for transmission:

$P_s=-\lambda Nt/1-(\lambda t+1)^N$

A busy period defines the channel transmission that can be either unsuccessful or successful and calculated as:

$B=T_sP_s+T_f(1-P_s)$

T_s represents the expected time period of successful transmission and T_f represents the expected time period of unsuccessful transmission.

4.2 Collision probability

A successful transmission period possesses transmission time of RTS packet, CTS packet and DATA packet, which monitored by τ. The successful cycle length is thus given as:

$T_c=\delta+2\gamma+3\tau$

Unsuccessful transmission periods possess multiple collided RTS packets. Since, the collision probability of RTS packets >2 is smaller than RTS packets =2, the packets >2 is neglected. The RTS packet transmission is similar to pure ALOHA transmission protocol. Since the assumption of Poisson arrival distributions (like memoryless and exponentially distributed inter arrival times), informs starting time of RTS packet collision to be distributed uniformly throughout the first RTS packet duration. Hence, the collision (average) duration is:

$$T_f = \int_0^{\gamma} (\gamma + x)\gamma^{-1} dx$$

The average utilization period (U) and idle period (I) over uniform time interval is expressed as:

$U=\delta \cdot P_s$ and $I=\lambda^{-1}$

4.3 Throughput analysis

The analysis of throughput is defined in terms of average duration between the effective packet transmission and unsuccessful packet reception or packet collisions. The DBTMA protocol in IEEE 802.11 communication is possess RTS/CTS dialogue mechanism. The Fig. 3 shows the timing duration of successful transmission of packet, a packet collided in transmission of RTS packet and packet collided in transmission during CTS period.

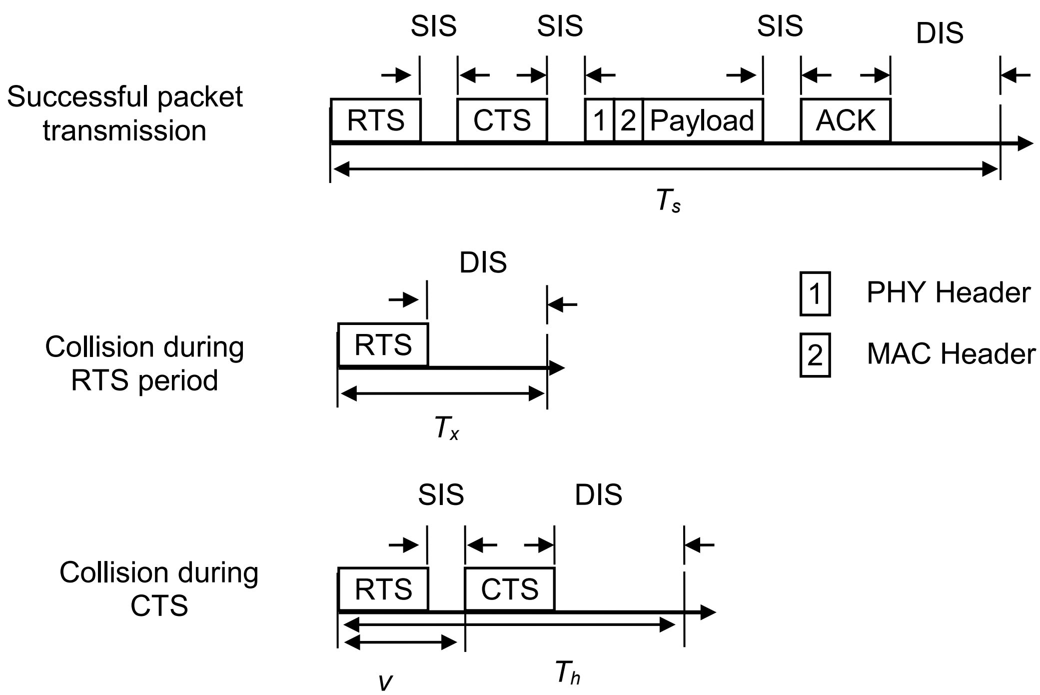

Figure 3: Packet transmission in the presence of hidden-terminals

The ACK, RTS and CTS denotes the timing duration of acknowledgement packets, ready to send packets and clear to send packets. The inter-frame timing, *SIS* and *DIS* denotes specifically the short and distributed inter-frame space, respectively. The T_s denotes the average time wasted by the channel, which senses the channel to be busy after the successful packet transmissions. The T_x denotes the time wasted due to collision of packets during the transmission of RTS packets. The T_h denotes the time wasted by packets collision due to the availability of hidden terminals. Hence,

$E[T] = RTS + SIS + \delta + CTS + SIS + \delta + H + E[P] + SIS + \delta + ACK + DIS + \delta$

where,

δ-Propagation delay.

H-Timing duration of PHY and DBTMA packet header

P-Timing duration of payload packet.

$T_x = RTS + DIS + \delta$ (3.10)

$T_h = RTS + SIS + \delta + CTS + DIS + \delta$ (3.11)

For simplicity, the value of T_h is considered as the worst case criteria, where the hidden node of the network collides with CTS transmission packet. The period v is given by:

$v = T + RTS + SIS + \delta$

The complete solution is obtained by considering a criteria situation where RTS/CTS dialogue mechanism is casted-off. Such situation is shown in Fig. 4.

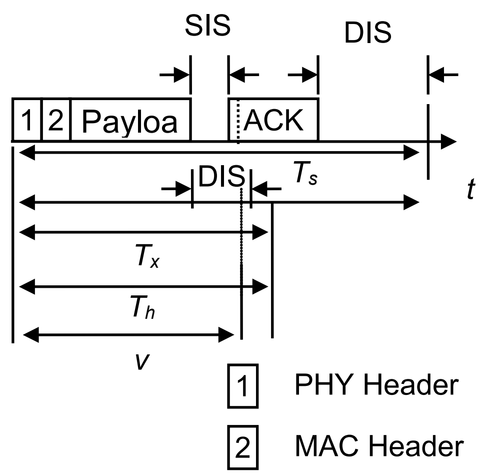

Figure 4: Packet transmission and collision

$E[T] = SIS + \delta + DIS + \delta + H + E[P] + ACK$

$E[T_x] = DIS + \delta + H + E[P]$

$E[T_h] = DIS + \delta + H + E[P]$

Hence, the period v is expressed as:

$v = SIS + \delta + H + E[P] + T$

Finally, T_H represents a per hop link node throughput that is considered as the percentage of transmitting time of a node (tagged),

$T_H = t_s/(t_i+t_s+t_o+t_c)$

where,

t_s-time spent after a successful transmission by node (tagged),

t_i -time when channel being sensed as idle around the node (tagged),

t_o-time of channel being used by other nodes,

t_c-time of node (tagged) facing collisions.

$t_s = a \cdot \mathrm{E}[T] \cdot p_n (1-p)$.

$t_i = (1-p_n) + P_i(1-a) - P_i (1-p_n)(1-a)$

$t_o = p_n ((1-P_i) (1-\mathrm{p})(1-a) \cdot \mathrm{E}[T] + (1-P_i)(1-\mathrm{a})(p_x \cdot \mathrm{E}[T_x] + p_h \cdot \mathrm{E}[T_h] - p_x p_h \cdot \mathrm{E}[T_h]))$

$t_c = a \cdot p_n (p_h \cdot \mathrm{E}[T_h] + p_x \cdot \mathrm{E}[T_x] - p_x p_h \cdot \mathrm{E}[T_h])$

Here,

p_n-probability of finding nodes of tagged node inside the transmission range with $A=\pi\lambda R^2$

P_i-is the probability t channel being sensed as idle around the node (tagged),

$p_n = 1-(1+A)\mathrm{e}^{-A}$

$P_i = e\text{-}aA-(1+A-aA)\mathrm{e}^{-A}/(1-a) \cdot p_n$

Finally, throughput of a single hop is defined as:

$T_{H\_hop} = (T_H \times \mathrm{E}[P])/\mathrm{E}[\mathrm{T}]$

4.4 Delay analysis

The delay analysis in MANETs requires the probability of successfully transmitted node that has achieved after multiple unsuccessful attempts say 'n'. The probability of which is given as:

$p_s(n) = p^n (1-p)$

The average value of unsuccessful attempts is:

$$n_a = \sum_{n=1}^{m+1} n p_s(n)$$

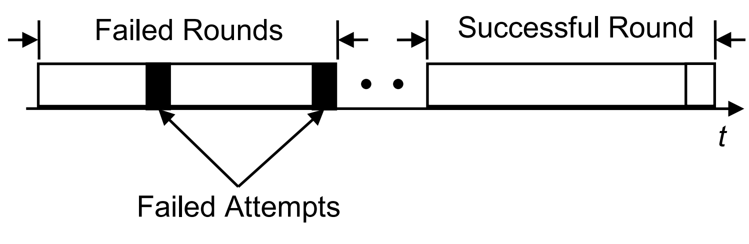

Figure 5: Rounds of transmission attempts

where m-limit of retransmission.

For a node (tagged), the time interval between the transmissions is divided into failed and successful rounds (Fig. 3). When the node fails, the channel spends time in idle state, successful transmissions and in collision. Hence, the total duration of failure round of tagged node is defined as:

$E[f]=(ti+tc+to)/a\ (1-a\ (1-p))$

The numerator operator defines the unsuccessful transmission time and denominator defines the probability of unsuccessful attempts. However, channel with successful attempts in idle states, successful attempts of other nodes and collision with other nodes and leads to channel with successful attempts. Hence, the successful duration of tagged node is:

$E[s]=(ti+tc+to)/a\ (1- ap))$

The numerator operator defines the successful transmissions without collision and denominator defines the probability of successful attempts without collision. The node (tagged) gets repeating itself over average of na rounds and then it delivers the packet. The packet waiting time (average) before successful transmissions is:

$w=E[f]\ na$

Finally, the packet delay (average) before each successful delivery is expressed as:

$d=E[s]+w$

4.5 Collision detection

In MANETs, a node is unable to transmit and receive packets concurrently, since the signal strength of the node is weaker than another nodes' signal. The receiver detects collisions through Cyclic Redundancy Check (CRC) and that fails due to noise in channel, hidden nodes and same back-off intervals. Since, failures with different causes possess varied solutions and the receiver node recognizes the failure reason through CRC. Conversely, the receiver fails in differentiating various failure types in MANETs. The access points reject the available packet and stops transmitting the ACK signal.

The detection accuracy over hidden collision is increased using following solution: Consider an access point that exploits a preamble in packet at its physical layer. The Pseudo-Random Noise (PRN) is made associated with the preamble in MANET communications that possess fixed pulse sequence. This pulse sequence is a deterministic periodic signal with an optimal solution, where the statistical properties look similar to Gaussian White Noise. The preamble does not dependent of other signals due the fact that it follows PRN properties. The preamble is detected in any situations i.e., during signal overlaps. Each time a signal is received at receiver, preamble correlation is done in order to whether the signal is correlated with the packet. When the preamble correlation exceeds the threshold time, then the detection of packet by receiver signals sets the value of the flag to 1. Thus, the access points identify the collisions in hidden nodes collisions, when a preamble is detected during the reception of a packet.

Here in this faster retransmission strategy, the access points decode the frame i.e., collided regardless of the hidden collisions. If the second frame arrives once the MAC header of first frame is received successfully, then the access point obtains the information on MAC, frame type and first frame duration. The proposed faster retransmission scheme exploits information for providing a fast retransmission strategy to the nodes that are getting collided.

5 Performance evaluation

Simulations are performed using Network Simulator-version 2.3 (NS-2.3) that uses parameters like route discovery delay and time, packet loss ratio, throughput and other related metrics etc., between the EDCA, DBTMA, RDBTMA and EDBTMA. Simulation results are given using NS-2.3 by comparing the parameters like delay, packet loss ratio, throughput, etc. between the DBTMA, RDBTMA and EDBTMA. Each simulation results signifies an average value over 50 random runs. The considered data rate of channel is 1 Mbps and nodes of 1000*1000 is used to simulate all the four protocols at MAC layer.

This section provides a clear comparison of various parameters related to the performance evaluation of proposed DBTMA protocols in MANETs. The quality of service (QoS) parameter guarantees the successful delivery of network traffic in MANETs. The requirements QoS classically refers to standard metrics that includes packet loss, packet delivery ratio, network throughput, route discovery delay, jitter, packet dropping ratio and so on. The dynamic change in network topology, bandwidth limited constraints, bandwidth quality and link variation pose additional constraints in MANETs to achieve the QoS required for the specific system.

The proposed method takes into account, the most important criteria that decides the QoS of MANETs i.e., control overhead. The presence of control message increases the consumption of bandwidth resource. Since, bandwidth is a premium resource for a network, the careful design should be made to maintain the control messages at minimum level. However, the use of control messages increases twice the consumption of bandwidth during transmission than reception. Hence, the reduction of control overhead will impact on energy consumption in the network.

The present study involves the comparison of various parameters associated with routing protocols of MANET. The standard metrics for comparison includes: total number of nodes, number of packets sent, number of packets received, packet delivery ratio, control overhead, normalized routing overhead, route discovery delay, network throughput, jitter, number of packets dropped dropping ratio, total energy consumption, average energy consumption, overall residual energy and average residual energy. The standard metrics are thus considered for QoS measurement in MANETs.

Minimal Control Overhead Control messaging consumes bandwidth, processing resources, and battery power to both transmit and receive a message. Because bandwidth is at a premium, routing protocols should not send more than the minimum number of control messages they need for operation, and should be designed so that this number is relatively small. While transmitting is roughly twice as power consuming as receiving, both operations are still power consumers for the mobile devices. Hence, reducing control messaging also helps to conserve battery power.

Quality of Service. A quality of service (QoS) guarantee is essential for successful delivery of multimedia network traffic. QoS requirements typically refer to a wide set of metrics including throughput, packet loss, delay, jitter, error rate, and so on. Wireless and mobile ad hoc specific network characteristics and constraints described above, such as dynamically changing network topologies, limited link bandwidth and quality, variation in link and node capabilities, pose extra difficulty in achieving the required QoS guarantee in a mobile ad hoc network.

Table 1: Results of various metrics

Total number of Nodes	100	125	150	175	200
Number of Packets Sent	1602	1602	1602	3202	1602
Number of Packets Received	1596	1557	1594	3199	1513
Packet Delivery Ratio	99.62547	97.19101	99.50062	99.90631	94.4444
Control Overhead	992	501	736	875	4154
Normalized Routing Overhead	6.32707	8.11882	0.483574	0.408879	7.04068
Delay	0.073086	0.022341	0.088267	0.020415	0.040199
Throughput	159400	155750	159500	239850	151250
Jitter	0.049611	0.049675	0.049028	0.02426	0.051557
Number of Packets Dropped	6	45	8	3	89
Dropping Ratio	0.374532	2.80899	0.499376	0.093691	5.55556
Total Energy Consumption	1.99898	1.56312	1.96439	0.579294	1.76128
Average Energy Consumption	0.020192	0.012606	0.013184	0.003329	0.008851
Overall Residual Energy	9889.36	12385.5	14883.7	17387.2	19878.1
Average Residual Energy	99.8925	99.8833	99.8909	99.9267	99.8899

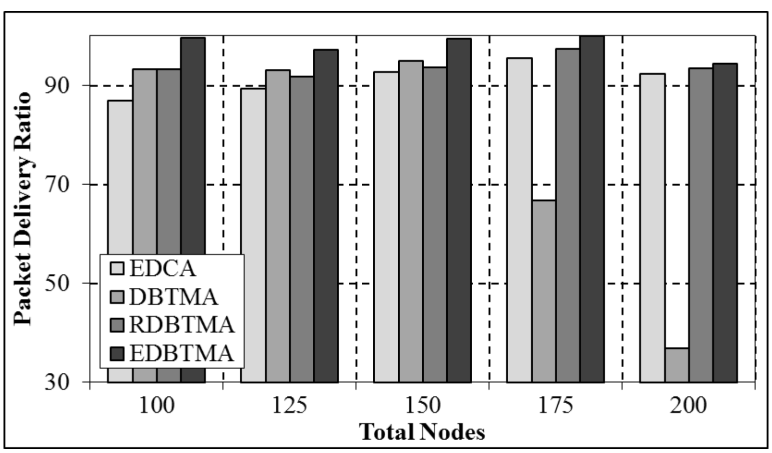

Figure 6: Packet delivery ratio

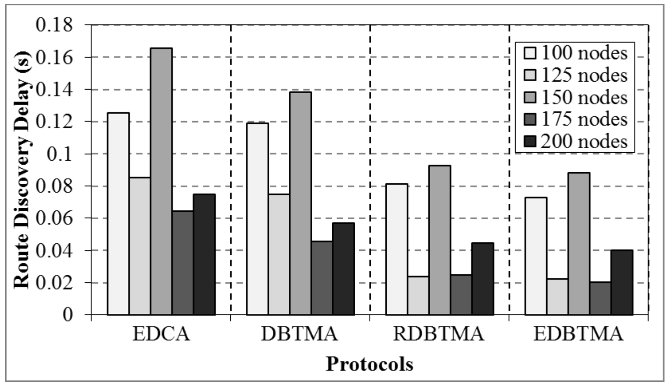

Figure 7: Route discovery delay

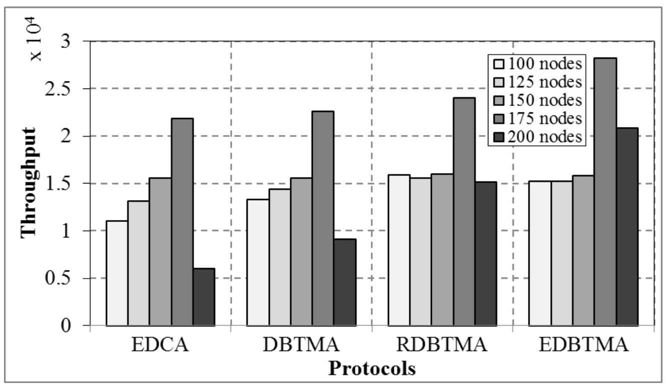

Figure 8: Throughput

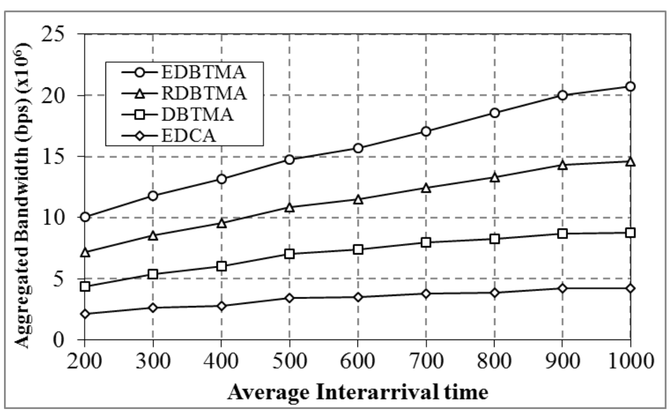

Figure 9: Aggregated bandwidth

6 Discussions

The comparison of standard QoS metrics is taken into consideration for evaluating the Enhanced DBTMA with CACP protocol. Total number of nodes is varied for evaluating the performance to prove dynamic nature of the protocol. The nodes are varied from 100, 125, 150, 175 and 200 for different evaluations, where the total packets sent on each 100, 125, 150 and 200 are 1602, and for 175 it is 3202. The total packets received for 100 nodes is 1596, for 125 it is 1557, 150 received 1594 packets, 175 with 3199 and finally 200 nodes in the network received 1513 packets. The transmission took place between two nodes in a network of nodes. The corresponding packet delivery ratio ranges from 94% to 99%, which is quite higher than RDBTMA protocol and the packet dropping ratio varies from 0.09% to 5.6%, which is lesser than RDBTMA.

This proves the effectiveness of the proposed protocol with lesser dropping of packets than RDBTMA in MANETs. However, the control overhead of the network seems decremented drastically, due to reduced control packets using CACP procedure. The routing overheads varying in range from 0.4 to 8%, which is lesser than RDBTMA. Additionally, it could be proved that the system could perform with lesser delay i.e., for 100 nodes, the route discovery delay is 0.071385 and so on. The total energy and overall residual consumption of the mobile nodes is reduced due to CACP and reduced control overhead. The throughput of the EDBTMA protocol seems promising with higher throughput rate than RDBTMA. The entire data on routing performance of Enhanced DBTMA is shown in Tab. 1.

The performance of the proposed schemes includes three concerns to be addressed: 1. Network throughput, 2. Bandwidth allocation, 3. Collision avoidance. Addressing these concerns using proposed protocols improves the metrics associated with it e.g., route discovery time, route discovery delay and faster transmission. The concerns are addressed through the modified DBTMA scheme resulted in following results:

- The Delay in DBTMA is inversely proportional to the scalability of route discovery. Here the scalability of the network increases by 1.46% using Retransmission DBTMA and 2.80% using Enhanced DBTMA.
- Secondly the throughput of proposed to Retransmission DBTMA increases to 1.60% than DBTMA and Enhanced DBTMA increases to 3.05% than DBTMA.
- When collision occurs in DBTMA, the fast retransmission strategy is used for improving the network performance using RDBTMA
- The interfacing DBTMA with Contention aware admission control (CACP) strategy effects in admission control that improves the bandwidth efficiency using EDBTMA.
- The impact of modified DBTMA MAC routing protocol over AODV protocol increases the network responsiveness in terms of collision avoidance, faster transmission, higher throughput and reduced delay.

7 Conclusions

In this paper, an Enhanced Dual Busy-tone Multiple Access (EDBTMA) protocol for 802.11 communications in MANETs is proposed. The proposed EDBTMA protocol avoids or reduces the impacts due to hidden terminal and exposed terminal problems using busy tone out band signals. Contention aware Admission Control Protocol performs the admission control inside and outside the transmission range of the nodes. The CACP possess local resource information and admission of new flows of the neighboring nodes. This enhances the broadcast and multicast reliability transmission and provides a better control function for admission control. The EDBTMA with CACP improves well the QoS of MANETs by providing better bandwidth allocation with network delay and jitter.

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